# COMPARATIVE STUDY OF THE PYROLYSIS CONDITIONS OF SUNFLOWER HUSKS FOR DESIGN OF LOW-COST CARBON ADSORBENTS

Hubetska T.S., Demchenko V.Ya., Kobylinska N.G.
A.V. Dumansky Institute of Colloid and Water Chemistry
National Academy of Sciences of Ukraine
blvd. Akad. Vernads'koho, 42. Kyiv, 03680, Ukraine
*kobilinskaya@univ.kiev.ua*

Biomass waste is a recyclable resource that obtained from agricultural residues every year. Conversion of biomass to biochar is one of the newer approaches to carbon sequestration in terrestrial ecosystems. Corn stalk [1], palm shell, tobacco stems, flower [2], nutshells, chickpea, husk, wood [3] and waste tea [4] are also widely used as raw material for biochars. The sunflower husk could lead to very high carbon content, giving this seeds a crucial advantage over other biomass materials in the energy generation and preparation of the corresponding biochar in the power plant.

The main idea of this work consists in the development of optimal conditions for the preparation of low-cost adsorbents from sunflower husk wastes as feedstock. To produce biochar with suitable costs, slow pyrolysis was used under laboratory conditions (400, 600, and 900 °C) and industrial-scale power generation kilns with pre-treatment stages (hot $H_2O$, $HNO_3$) of the samples. This approach is conveys feedstock (biochar) using for obtaining activated carbons (ACs) by chemical activation ($HNO_3$, $H_2O_2$+$HNO_3$) The properties of sunflower waste-based were characterized by elemental analysis, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM), Energy-dispersive X-ray spectroscopy, thermogravimetry analysis with mass detection (TGA-MS) and adsorption tests.

Biochar under laboratory conditions it is possible obtain by pyrolysis starting from low temperature (400 °C), taking into account that with a higher temperature, less treatment time is required. The biochars used in this study were prepared with a temperature range from 400 to 900 °C and short treatment time.

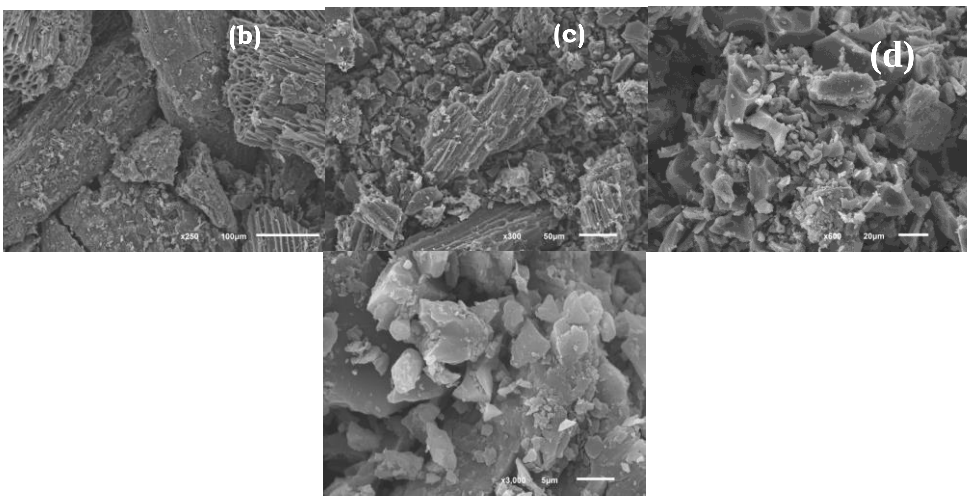


**Fig. 1.** SEM images of initial biochars obtained at various carbonization temperatures (a) 400°C, (b) 600 °C, (c) 800 °C and (d) 900 °C.

The SEM images of the materials demonstrate that the biochar retains the initial structure of hollow polyhedral cell of the raw material does not depend on the pyrolysis conditions (***Fig. 1***). These results clearly show that remaining cellulose [5] is the major contributor to biochars. These results are in perfect agreement with those obtained via TGA-MS data (***Fig. 2***). Activation of all kinds biochars with $HNO_3$ caused much more extensive destruction of the structure of the particles, leading to a more homogeneous particle size distribution of the carbonaceous materials. However, the presence high intense peaks at 150 °C, corresponding to the residual $HNO_3$ in the ACs compared to the all initial biochars as results of acid activation (***Fig. 2***).

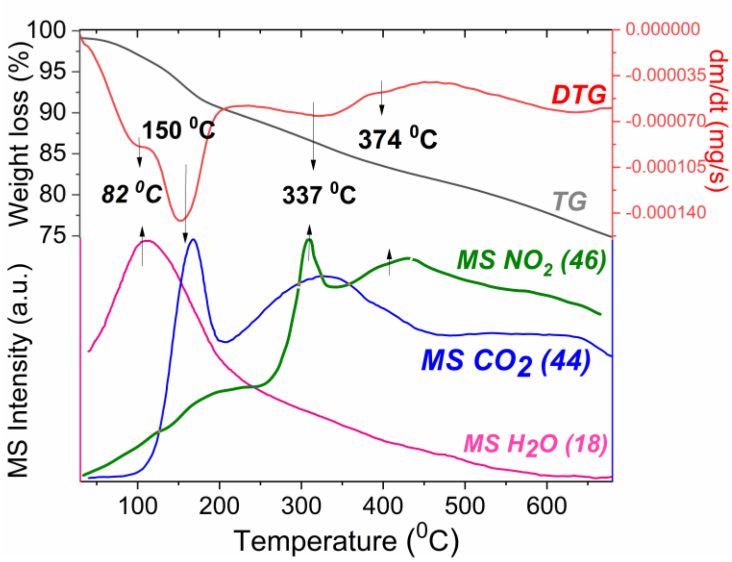


**Fig. 2.** TGA curves and mass spectra of selected ions ($H_2O$, $NO_2$ and $CO_2$) of ACs prepared using industrial-scale biochar activated by $HNO_3$

It should be noted that after industrial pyrolysis a large number of pores are formed in the cell walls, and furthermore the cells are connected to each other through these open pores. Experimental data shown that the sunflower-based biochar produced under laboratory pyrolysis conditions has higher aromaticity and polarity. The adsorption capacity of ACs obtained by laboratory pyrolysis at 900 °C combined with $H_2O_2$+$HNO_3$ activation exhibit highest adsorption capacity to methylene blue as model analyte.

Also, ACs obtained by industrial pyrolysis exhibit superior adsorption capacity toward $Co^{2+}$ ions (34.5 mg/g) with a shorter equilibrium time (1 h), which gives its a competitive advantage to similar adsorbents. The study opens up possibilities for the development of highly efficient adsorbents via a straightforward, eco-friendly approach, with specific focus toward the economic effect achieved.

**Acknowledgements.** Dr. *T.S. Hubetska* is grateful for financial support from MINECO (MAT2016-78155-C2-1-R) and Becas Iberoamérica Santander Investigación 2020/2021.

**References:**


1. Wang ZQ, Wu JL, He T, Wu JH. Corn stalks char from fast pyrolysis as precursor material for preparation of activated carbon in fluidized bed reactor. Bioresour. Technol. 2014; 167: 551-554.
2. Angın D, Köse TE, Selengil, U. Production and characterization of activated carbon prepared from safflower seed cake biochar and its ability to absorb reactive dyestuff. Appl. Surf. Sci. 2013; 280: 705-710.
3. Mohan D, Pittman CU, Steele PH. Pyrolysis of wood/biomass for bio-oil: a critical review. Energy Fuel. 2006; 20: 848 – 889.
4. Gurten II, Ozmak M, Yagmur E, Aktas Z. Preparation and characterisation of activated carbon from waste tea using $K_2CO_3$. Biomass and Bioenergy. 2012; 37: 73-81.
5. Zhang J, Zhang W. Preparation and characteristics of activated carbons from wood bark and its use for adsorption of Cu(II). Mater. Sci. 2014; 20: 474–478.